Written Testimony to the United States House of Representatives Energy & Commerce Committee, Subcommittee on Energy and Power

"The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System"

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Summary

The National Academy of Engineering has identified the electrical grid as the most important scientific achievement of the 20th century. That infrastructure is now being substantially upgraded and the resultant advanced smart grid will be one of the largest and most complex machines ever conceived. The Smart Grid will likely prove to be one of the most significant scientific achievements of the 21st century.

It is estimated that as much as $2 trillion is being invested this decade in upgrading the power infrastructure globally to make the devices in the power grid remotely machine addressable. The most common example is the smart meter that allows the grid operator to remotely sense the electric or gas meter's state in near real time. As the grid becomes increasingly sensored, it becomes a fully connected sensor network (think of it as the Internet of Energy) and unprecedented amounts of data are produced. These data can be integrated, processed, and analyzed using state-of-the-art information technology in a manner to optimize the power generation and distribution value chain.

C3 Energy is a private sector response to this challenge and opportunity, harnessing the power of big data, social networking, cloud computing, human-computer interaction models, and machine learning to realize advances in safety, reliability, cost efficiency, and security of power generation and delivery – unlocking a benefit of up to $300 per meter, per year, in recurring annual economic benefit for U.S. utilities, retailers, and their energy customers.

Progress has been dramatic in the current decade. That being said, current state rate regulations have not kept pace with, and actually impede, the ability of utilities to benefit from the new IT models. Utility regulatory agencies should be encouraged to allow rate recovery for cloud-based SaaS license arrangements. This change will accelerate the adoption curve and

accessibility of today's innovative computing models and reduce the current, unnecessary barriers to technology advancement in the utility industry. This is an essential step in the transformation to a smarter, more efficient, and more sustainable energy system.

The Power of the Smart Grid

Thomas M. Siebel

A sociologist from Harvard by the name of Daniel Bell published a book entitled *The Coming of Post-Industrial Society* in 1976 in which he predicted what we know of today as the Information Age. Years before the conception of the Internet, the minicomputer, the personal computer, and the cell phone, Bell predicted that information and communications technology would effect a fundamental change in the structure of the global economy, a change on the order of magnitude of the Industrial Revolution.

This information revolution would portend the preeminence of the "knowledge worker" and result in the emergence and growth of the information technology industry, driving fundamental and ubiquitous changes in the ways we work, communicate, and operate business processes.

With the advent of the utility smart grid, Bell's predictions meet the business value chain associated with power generation, transmission, distribution, consumption, and energy efficiency.

In the United States, more than 3,270 utilities[1] are responsible for operating the grid and delivering over 1,100 GW[2] of power capacity to nearly 150 million electricity customers,

[1] "Electric Power Industry Overview 2007." U.S. Energy Information Administration, n.d. Web. 26 Feb. 2015. <http://www.eia.gov/electricity/archive/primer/>.
[2] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Electricity Generation Capacity*. U.S. Energy Information Administration, 2011. Web. 26 Feb. 2015.

generating revenues of $376 billion per year[3]. Globally, the electric power industry delivers over 5,500 GW of capacity[4].

It is estimated that as much as $2 trillion is being invested this decade in upgrading the power infrastructure globally to make the devices in the power grid remotely machine addressable[5]. Almost $1 trillion of this investment will occur in the United States[6]. These devices include meters, thermostats, home appliances and HVAC equipment, factory equipment and machinery, transformers, substations, distribution feeders, and power generation and control componentry.

The smart grid is advancing at a rapid rate. A nascent market at the beginning of the 21st century, as of 2015 over 310 million smart meters have been installed globally. That number will more than triple by 2022, reaching nearly 1.1 billion[7]. While representing only a fraction of the sensors on the grid infrastructure, the smart meter installation numbers provide a good indication of the penetration and rate of growth of the smart grid. These developments are occurring worldwide.

The truth is that the smart meters and other smart devices themselves provide little utility. They simply provide the capability to remotely sense a device's state. For example, is the device operative or inoperative? If operative, at what velocity, voltage, or amperage? It might allow us

[3] *Form EIA-861 Detailed Data Files* (n.d.): n. pag. *Annual Electric Power Industry Report*. U.S. Energy Information Administration, 19 Feb. 2015. Web. 26 Feb. 2015. <http://www.eia.gov/electricity/data/eia861/>.
[4] "International Energy Statistics - EIA." *International Energy Statistics - EIA*. U.S. Energy Information Administration, 2012. Web. 26 Feb. 2015.
[5] Electric Power Research Institute (EPRI), "*Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid*" (2011).
[6] "EEI to Wall Street: The Future Is Here." *EEI Newsroom*. Edison Electric Institute, 11 Feb. 2015. Web. 27 Feb. 2015. <http://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20to%20Wall%20Street%20The%20Future%20is%20Here.aspx>.
[7] Navigant Research. *Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts*. Chicago: 3Q 2014.

to know the amount of energy that the device has consumed or recorded over some period of time or is consuming in real time.

Collectively, these sensors generate massive amounts of information. With recent developments in information technology, including elastic cloud computing and the sciences of big data, machine learning, and emerging social human-computer interaction models, we are able to realize the economic, social, and environmental value of the smart grid by aggregating the sum of these data to correlate and scientifically analyze *all* of the information generated by smart grid infrastructure in real time.

Today, each component of the power value chain, from generation, transmission, distribution, metering, to customer consumption, is supported by multiple, independent, information technology systems that are not designed to work with each other and therefore prevent data sharing, data analysis, and interoperability. This results in high levels of inefficiency and risk.

As the sensored smart grid is enabled, by holistically correlating and analyzing all of the dynamics and interactions associated with the end-to-end power infrastructure—including current and predicted demand, consumption, electrical vehicle load, distributed generation capacity, technical and non-technical losses, weather, and generation capacity—across the entire value chain, we can realize dramatic advances in safety, reliability, infrastructure security, and energy efficiency.

Smart grid analytics enable us to provide real-time pricing signals to energy consumers, manage sophisticated energy efficiency and demand response programs, conserve energy use, reduce the fuel necessary to power the grid, reconfigure the power network around points of failure, recover instantly from power interruptions, accurately predict load and distributed generation capacity, rapidly recover from damage inflicted by weather events and system failures, prevent cyber attacks, and reduce adverse environmental impact. The advent of smart grid analytics represents a major advance in the development of energy efficiency technology.

Many leading utilities including Enel, GDF Suez, and Exelon are driving innovation by applying the science of big data and smart grid analytics to the benefit of their communities, consumers, and stakeholders.

At C3 Energy, we are committed to advancing the state-of-the-art of smart grid analytics in the hope of making a substantial contribution to the important dialogue on the future of energy.

The rapid growth of sensor investments in the smart grid opens up a new opportunity for utilities to take advantage of next-generation information technology including elastic cloud computing, analytics, machine learning, and social human-computer interaction models to fully unlock the insights and value that a modern grid has to offer. Current state utility rate regulations however, have not kept pace with, and actually impede, the ability of utilities to benefit from the new IT models that will substantially improve system performance, reduce capital and operating costs, and produce substantial economic value to utility customers and shareholders.

Under current guidelines, a utility may generally classify investments in legacy hardware and supporting on-premise software as a capital expense, which can be included as part of the rate case on which it can receive a guaranteed rate of return. Counter-intuitively, if a utility invests in state-of-the-art cloud-based technologies that offer immense economic and social benefit, it typically must treat the investment as an operating expense for which it does not receive a rate of return, resulting in decreased cash flow and lower profitability.

This establishes a perverse incentive for U.S. utilities to pursue more costly, less effective, and riskier on-premise technology investments, depriving ratepayers of the performance and economic benefits of the more advanced technology innovations that many other industry sectors are now experiencing. The effect is to deprive ratepayers of the benefits of innovation.

Utilities are investing billions of dollars to make the devices in the power grid remotely IP-addressable, including the nearly 1.1 billion smart meters that will be installed by 2022[8]. While representing only a fraction of the sensored devices on the grid, the number of smart meters provides a good indication of the growth rate of the smart grid.

McKinsey & Company has estimated that widespread use of big data analytics solutions could cut more than $50 billion per year from electricity bills in the U.S. Globally, the opportunity is $300 billion[9] annually. Smart grid analytics solutions across the entire power value chain can deliver $1.5 billion in recurring annual economic benefit to a typical integrated, 5 million meter U.S. utility and its customers[8]. That is a very real private sector stimulus for the economy.

[8] Navigant Research. *Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts*. Chicago: 3Q 2014.
[9] Client Study, McKinsey & Company: February 2013.

I would like to share a few examples of these "big data" smart grid analytic solutions and their benefit to U.S. consumers. The following estimates are based upon research conducted by McKinsey & Company.

Predictive Maintenance applications help utilities predict asset failure and take proactive action, saving customers $18 to 20 per year[10].

Revenue Protection applications help identify energy theft and asset malfunctions, saving each customer $8 to 10 per year[11].

Grid Cybersecurity applications secure grid reliability and help utilities identify and reduce the grid cyber attack vulnerabilities, saving customers $8 to 10 per year[12], in addition to mitigating national security risk.

Voltage Optimization applications reduce unnecessary power generation and deliver higher-quality power, saving each consumer $25 to 36 per year[13].

Some of the world's leading utilities, such as Exelon in the U.S. and Enel in Italy, are among the first to use these new technologies to deliver substantial savings from their grid modernization investments.

[10] "Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid." EPRI, Palo Alto, CA: 2011. 1022519.
[11] Ibid.
[12] Ibid.
[13] "Volt/VAR Control and Optimization Concepts and Issues", EPRI, 2011.

Baltimore Gas and Electric (Exelon Corporation) in the United States[14,15]

In 2014, Baltimore Gas and Electric Company (BGE), a subsidiary of Exelon Corporation, launched two of C3 Energy's smart grid applications across the two million meters in its service territory. BGE is leveraging C3 AMI Operations™ to optimize the deployment and ongoing health of its advanced metering infrastructure (AMI) network and C3 Revenue Protection™ to identify and reduce unbilled energy usage. BGE expects these applications to deliver an annual economic benefit of $20 million to BGE and its customers. Deploying the smart grid analytics platform across the three Exelon utilities is estimated to result in $383 million in recurring annual economic benefit to Exelon and its consumers.

The deployment of C3 AMI Operations and C3 Revenue Protection involved unprecedented levels of data integration at BGE, requiring 42 integrations to 12 source information systems. C3 Energy loaded two years of historical BGE data into a 10-terabyte federated cloud image and configured more than 140 complex analytic and predictive algorithms to meet BGE's requirements.

C3 Revenue Protection identified over 15,000 non-technical loss cases (energy theft) with field investigation accuracy rates of 90%, spurring BGE to develop a new back-billing process to handle the large volume of identified cases. During the same timeframe, C3 AMI Operations identified 3,600 meter health problems with a 99% accuracy rate, avoiding many billing errors.

[14] "Baltimore Gas & Electric Wins Project of the Year for Deployment of C3 Energy Smart Grid Applications." *C3 Community*. C3 Energy, 3 Feb. 2015. Web. 26 Feb. 2015.
[15] *Case Study: Exelon | Driving Grid Efficiency and Revenue Protection Efforts*. Rep. Redwood City: C3 Energy, 2015. Print.

The primary economic benefit comes from identifying and resolving unbilled energy usage, which reduces the cost of non-technical energy losses—a cost typically passed on to customers. Additional benefit derives from detecting problems with meters or with the communication network. This reduces the amount of missing usage data and increases billing accuracy and the overall effectiveness of the AMI meter deployment. These benefits represent a significant improvement over the benefits of smart grid infrastructure alone.

Other benefits come from the streamlining of existing BGE business processes across smart grid operations, revenue management, and field operations, saving time and effort and increasing customer satisfaction. The solutions also provide safety benefits. C3 AMI Operations and C3 Revenue Protection reduce risks to customers and utility employees in the field by alerting users to potentially hazardous meter conditions, such as unsafe meter temperature or potential meter tampering.

Enel in Italy[16]

Enel is one of the world's largest utilities, and the first utility to replace traditional meters with smart meters at scale—currently more than 40 million meters are installed, or 80% of all smart meters in Europe. In total, Enel operates 67 million meters in 40 countries. At Enel Italy, we integrate and process over 50 billion rows of data from 11 legacy systems, and have identified 93% of likely cases of theft or other non-technical loss. This is the largest smart grid analytics deployment in the world. The economic benefit of Revenue Protection and Predictive Asset Maintenance analytics for Enel, in Italy alone, is estimated to exceed €350 million annually.

[16] "Enel: Improving Smart Grid Reliability and Operational Efficiency." *Innovations Across the Grid | Partnerships Transforming the Power Sector* II (2014): 153-55. The Edison Foundation - Institute for Electric Innovation, Dec. 2014. Web. 26 Feb. 2015. <http://www.edisonfoundation.net/iei/Documents/IEI_InnovationsGrid_volII_final_LowRes.pdf>.

Because smart grid analytics technology produces far more savings than costs, it does not need any financial assistance or incentives from the federal government to succeed. But success will advance more rapidly if regulatory obstacles are removed. For example, by updating rate regulations to recognize Software as a Service products as the equivalent of a capital expense, and by updating rules and guidance to encourage utilities to add analytics solutions to their planned budgets for grid modernization, progress will accelerate.

All of the hardware sensor advances on the grid are of limited usefulness without the cloud-based software innovations that will actually make the grid "smart". As the grid becomes increasingly sensored, an unprecedented amount of data are produced, that can only be addressed using the state-of-the-art information technology. IT offerings have rapidly evolved into today's innovative cloud computing models, including Software as a Service, Platform as a Service, and Infrastructure as a Service. With these come opportunities to leverage numerous capabilities essential to fulfilling the promise of the smart grid – continuous access to increased processing speeds and power, more flexibility and mobility, elasticity/on-demand surge capacity, and lower costs through scale.

The majority of IT innovation and development in the 21st century is focused upon next generation, cloud-based, Software as a Service (SaaS) computing models. The acceleration of this trend is breathtaking, with examples in the news daily from leading companies including Google, Facebook, Amazon Web Services, and Apple. CISCO recently predicted that by 2018, more than three-quarters of all corporate information will be processed via the Internet cloud

rather than internal company computer servers[17]. Just last week, Ginni Rometty, CEO of IBM, announced a $4 billion new investment in cloud-based technology development, predicting that 40% of IBM's expected total revenues will accrue from cloud computing by 2018[18].

The U.S. regulatory treatment of cloud computing models has not kept pace to allow utilities to take advantage of these technology innovations, and utilities are faced with adverse consequences when they select modern cloud computing solutions. The existing guidelines are based on decades-old regulatory models that classify last-generation on-premise software licenses as capital expenses, and modern cloud computing arrangements as operating expenses. The classification as a capital versus operating expense influences a utility's ability to obtain rate-base coverage consistent with other capital expenditures, effectively incenting investments in antiquated technology.

To enable the goal of a modern electric transmission and distribution system, advanced cloud-based IT offerings are necessary. Regulators should respond by removing barriers and providing incentives to deploy cost-saving, high-performing 21st century software systems similar to those that a utility receives for investing in other capital infrastructure, including 20th century IT systems.

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[17] Barlas, Pete. "Cisco Systems: Cloud Will House Most Data By 2018."*Investors Business Daily*. Investors.Com, 4 Nov. 2014. Web. 1 Mar. 2015. <http://news.investors.com/technology/110414-724654-cisco-forecasts-huge-cloud-growthcisco-systems-cloud-will-house-most-data-by-2018.htm#ixzz3IcFWDjsj>.

[18] Clark, Don. "IBM Pumps $4 Billion Into Cloud and Mobile Initiatives." Wall Street Journal, 26 Feb. 2015. Web. 02 Mar. 2015. <http://www.wsj.com/articles/ibm-pumps-4-billion-into-strategic-imperatives-1424959681>.

Cloud Computing

Over the last decade, a rapidly growing number of companies have shifted from buying on-premise software components under perpetual or term licenses to leveraging cloud-based, SaaS software built, managed, and continually improved by the technology vendor. These companies are replacing traditional on-premise software applications and platforms – even the underlying IT infrastructures – with these cloud-based computing solutions.

Cloud computing refers to the use of Internet-based computing to deliver a variety of product offerings. Under cloud computing arrangements, the customer has a right to use or benefit from the functionality of software but does not receive a copy of it.

The most common cloud computing models for utilities are Software as a Service (SaaS). With a SaaS model, utilities pay to use an Internet-based software product hosted by the SaaS solution provider. With SaaS models, the solutions are essentially rented by the utility instead of purchased outright. This allows utilities access to the latest advances in technology, mobility, elasticity, and scalability to realize operational efficiencies, without having to invest capital in hardware and software to meet their requirements. However, regulation has not kept apace, and despite the efficiencies available, utilities are not incented to invest in these solutions and are effectively encouraged to continue to procure obsolete technology.

Solutions

Utilities should not be penalized for or discouraged from investing in technology advancements. Instead, utilities should be encouraged to lead the way to a more modernized electric system. In order to do so, they need modification to rate recovery rules on a state by state basis to support a model rule to benefit from rate recovery from modern cloud computing solutions.

To move forward, utility regulatory agencies should be encouraged to allow rate recovery for SaaS license arrangements. This change will accelerate the adoption curve and accessibility of today's innovative computing models and unlock the scalability, elasticity, performance power, integration speeds, and cost/benefit for utilities and their customers. The classification of SaaS in a manner to allow rate recovery will remove the current regulatory barriers towards technology advancement in the utility industry, which is an essential step in the transformation to a smarter, more efficient, and more sustainable energy system. State utility regulatory agencies should consider allowing utilities rate recovery from 21st century information technology, providing ratepayers the many significant benefits of IT innovation.

Speaker Biography

Thomas M. Siebel is the Chairman and Chief Executive Officer of C3 Energy, where he leads an accomplished team of machine learning, computer science, power system, and engineering experts to tackle one of the toughest technology challenges—to apply the science of big data and machine learning to today's energy industry to unlock significant value across the power grid. As the founder, chairman, and CEO of Siebel Systems—one of the world's fastest-growing software companies, Mr. Siebel built the foundation of the CRM market. Founded in 1993, Siebel Systems rapidly became a leader in application software with more than 8,000 employees in 32 countries, over 4,500 corporate customers, and annual revenue in excess of $2 billion before it merged with Oracle Corporation in January 2006.

Mr. Siebel serves on the Board of Advisors for the University of Illinois at Urbana College of Engineering, and the University of California at Berkeley College of Engineering. He is a Director of the Hoover Institution at Stanford University and is the Chairman of the Board of the American Agora Foundation. He was elected to the American Academy of Arts and Science in 2013.

Mr. Siebel is a graduate of the University of Illinois at Urbana-Champaign, where he received a B.A. in History, an M.B.A., and an M.S. in Computer Science.

About C3 Energy

C3 Energy was founded in 2009 by a highly experienced team of executives with deep experience in software, analytics, and cloud computing, and a long track record of serving enterprise customers. C3 Energy is a SaaS and PaaS enterprise application software company that harnesses the power of big data, smart grid analytics, social networking, machine learning, and cloud computing to improve the safety, reliability, and efficiency of power generation and delivery. C3 Energy's family of utility-tested and proven smart grid analytics products deliver end-to-end solutions across the entire smart grid, from energy grid capital asset allocation, transmission, distribution, and advanced metering, to the customer experience and energy efficiency programs. C3 Energy products enable utility operators to realize the full benefit of their smart grid and energy system investments.